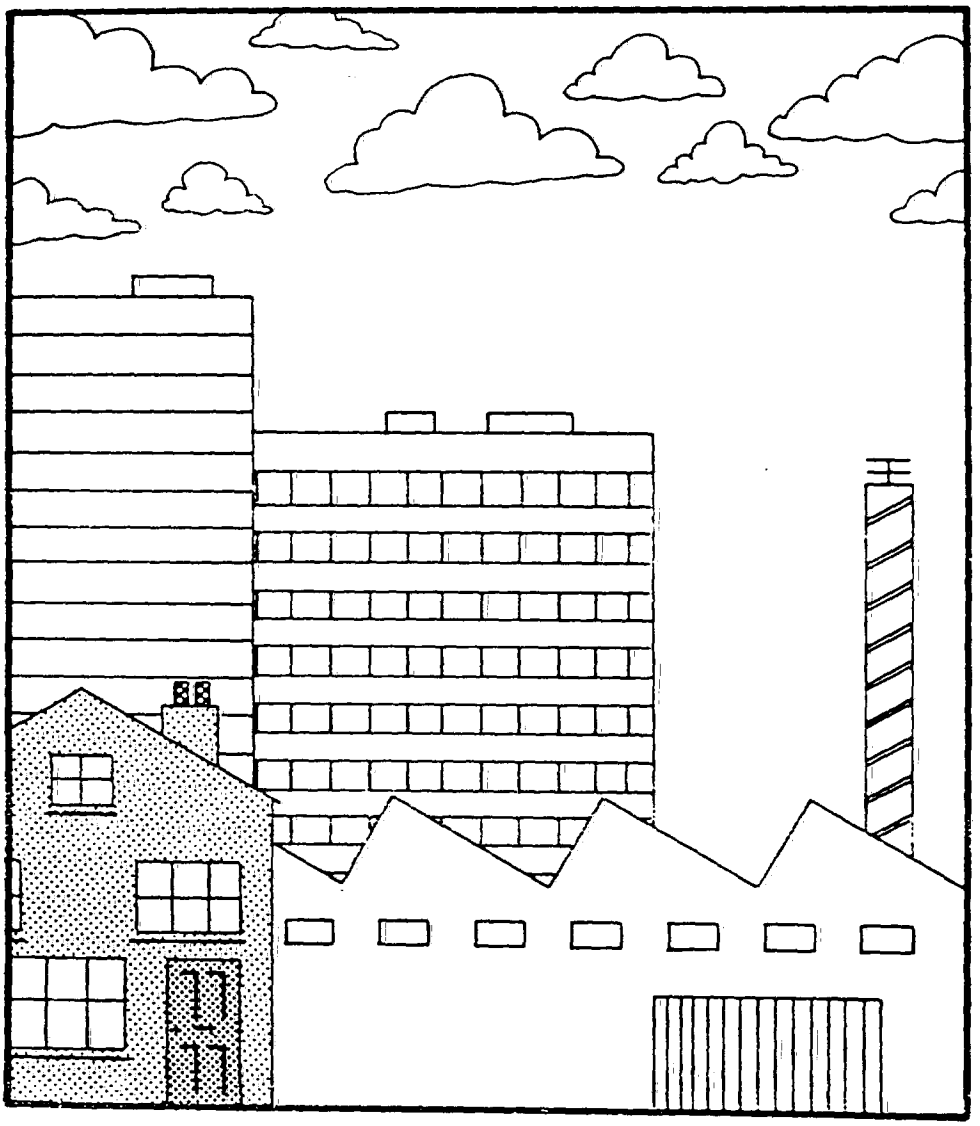
INDOOR AND AMBIENT AIR QUALITY



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ASHRAE: ADDRESSING THE INDOOR AIR QUALITY CHALLENGE WITH ENERGY CONSCIOUS DESIGN

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ABSTRACT

The paper reviews how the issue of poor indoor air quality is affecting the heating, ventilation, air-conditioning, and refrigerating industry and emerging technology; the position of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) on indoor air quality; the impact of ASHRAE's revision of Standard 62, "Ventilation for Acceptable Indoor Air Quality," which is expected to be approved in 1988; the importance of the indoor air quality issue in the United States; recently approved and pending legislative and regulatory activities; and ASHRAE's role in providing safe and healthy environments in regards to indoor air quality.

It is a pleasure and honor to join you at this International Conference on Indoor & Ambient Air Quality. The interest of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) in indoor air quality goes back to the formation of the organization's predecessor society in 1895. Today, the activities of ASHRAE in the area of indoor air quality (IAQ) and ventilation include research, standards-writing, and education through seminars, conferences, speaking engagements, and publications.

In 1895, the recommended ventilation rate was 30 cubic feet per minute (cfm) of air per person. This amount of outdoor air was found to be necessary to control human body odor in buildings. Odor, a primary component of air quality was the issue. As personal hygiene improved in the early part of this century, ventilation rates were reduced.

Recently, IAQ has been a subject of increased concern because indoor contaminant levels and exposures frequently exceed those encountered outdoors, many new products are being introduced into the indoor environment that provide increased levels of exposure, and energy conservation measures that reduce ventilation rates can elevate indoor contaminant concentrations. Let me note that inadequate ventilation is not a source of indoor contaminants but, rather, allows contaminant levels from existing sources to be elevated.

Researchers have learned that indoor air contaminants may affect occupants' health by causing discomfort, annoyance, or even well-defined diseases. These illnesses result in reduced employee productivity and thousands of dollars in lost manhours. When the sources of indoor pollution are identified and the problems corrected, the pattern of increased employee absenteeism is immediately reversed. Initially, the problem is to identify the sources of indoor air contaminants. Contaminants may originate from the building's furnishings and materials, equipment operation, and occupants and their activities.

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An additional major source of indoor pollution may be the outdoor air which is taken into a building. The results of an indoor air quality study conducted by the National Institute for Occupational Safety and Health found that in 11 percent of the 446 buildings investigated the source of the poor air quality was the outdoor air. The intake air may be polluted with carbon monoxide, nitrogen dioxide, and hydrocarbons from automobile exhaust, as well as hydrocarbon exhaust from commercial kitchens.

From my experience of environmental engineering in heavy industry, some conclusion can be drawn from the accumulation of knowledge in this technology that address indoor air quality:

* Adequate Make-Up Air. Used for positive pressurization, large quantities of make-up air were necessary to insure against infiltration from structural leakage and door openings and traffic; large equals 20 to 40 percent and as much as 100 percent outside air. What does this tell us about the IAQ problem of inadequate ventilation air for indoor air quality?
* Treated Outside Air. Extensive filtration treats outside air to preclean it from gas phase and particulate contaminants; often, dropping sulphur concentrations by three orders of magnitude from part per million range to low part per billion range. Is your outside make-up air really clean enough to provide contaminant reduction through dilution or are you merely re-entraining more of different contaminants?
* High Internal Air Change Rates. Cleansing air to fractional part per billion contaminant range requires repeated and constant scrubbing by sorption and filtering units. Sometimes 10 and 20 air changes are not unusual. What does this say to us about VAV systems with "zero" air change or the whole issue of ventilation efficiency?
* Humidity Control. The conditioned space requires tight humidity control in the 50 to 55 percent range, but also demands very low variations of relative humidity, no more than two percent variation an hour. This gives us some clue as to the need to understand the inter-relationship of moisture content or air, either relative or absolute, with contaminant levels and perception phenomenon.

At the ASHRAE-sponsored conference IAQ 87, a case was cited in which outdoor air contaminated an office building, resulting in an employee absenteeism increase of 600 percent for two consecutive months compared to the same two-month period in the previous year. The employer was alarmed when manhour losses soared from 50 hours in April and May, 1985, to 300 to 350 hours in April and May, 1986. The outdoor air problem was caused by grease fumes emitted from a restaurant. After the restaurant's grease fumes were discharged, they were not diluted by being carried up above the building. This is fundamental in the prevention of indoor air quality problems. In downtown locations, exhaust fumes should be released at the highest point of the source building. After $25,000 in lost manhours in a five-month period, after a 600 percent increase in employee absenteeism in a two-month period, and after five months of negotiations, the restaurant owner agreed to install a new fan and ductwork. However, odors still persist to this day.

Building designers need to carefully evaluate the air flow over buildings and the air movement around buildings to minimize the amount of contaminated air entering occupied spaces. Once contaminated outdoor air has entered an office building, it will affect employee health, comfort, productivity, and absenteeism. The environmental controls for buildings need to serve three basic functional needs: comfort, health, and productivity.

Many cases of so-called "sick buildings" have been investigated, and physical causes for occupant complaints documented. Causes of poor indoor air quality include lack of system maintenance, changes to thermal and contaminant loads imposed during the lifetime of the building, changes in control strategies to meet new objectives during the lifetime of the building, and inadequate design of the original system. Problems of inadequate design include inadequate outdoor makeup air for ventilation, contaminated makeup air, poor air distribution within buildings and rooms, and unbalanced exhaust air.

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Once ventilation air has entered the building it must be properly distributed to occupants to avoid poor or bad ventilation. If portions of a building are leased to tenants, redesign of that space, such as erecting partitions or changing an executive office to a conference room, can dramatically affect the air distribution design or the required ventilation rate.

In 1973, ASHRAE published its first standard directly addressing ventilation: Standard 62-73, "Standard for Natural and Mechanical Ventilation." This standard specified ventilation rates using two sets of criteria: minimum ventilation rates to accommodate energy conservation (typically 5 cfm per person) and recommended ventilation rates for comfort in odor-free environments (typically 15 cfm per person). Other important considerations included the recognition of recirculation air and filtration systems for ventilation and the need for cleaning outdoor air when its quality was not acceptable. No mention was made, however, of the the nature of indoor pollutant sources and their impact on indoor air quality.

In response to concerns about energy consumption in buildings, in 1975 the organization published ASHRAE Standard 90-75, "Energy Conservation in New Building Design." Standard 90, which has been adopted in whole or in part by building codes in all 50 states in the United States, recommended that the minimum ventilation rate in Standard 62 be used for design purposes. This requirement had the effect of eliminating the established recommended values for ventilation and caused concern that the quality of indoor air would be compromised. When Standard 62 was revised and published in 1981 it listed required ventilation rates for nonsmoking and smoking areas rather than minimum and recommended values. Other criteria in addition to no smoking were required for designing a system utilizing 5 cfm, such as special air cleaners. A no smoking environment was, by itself, not sufficient for 5 cfm.

ASHRAE Standard 62-1981 is now being revised and is expected to be published this year. It is helpful to consider some of the major changes that have been made and the rationale for these changes. The distinction between smoking permitted and smoking prohibited has been abandoned, therefore reaffirming ASHRAE's recommended ventilation rates. The proposed revision to Standard 62 recommends the same cfm for office spaces as the existing standard recommends for that same space if any smoking is allowed. After all, how many office buildings are truly managed and operated as strictly non-smoking buildings?

Research undertaken since 1981 shows that occupants have a negative response to CO2 at a room concentration of 0.25 percent (the level with 5 cfm). Previously, it was assumed from experience with submarines, industrial settings, and bomb shelters that healthy people could tolerate 0.5 percent CO2. On that basis, it was thought that 0.25 percent CO2 was a sufficient safety margin.

More recent studies show, however, that the space will develop considerable odors and occupants will find the atmosphere stuffy and too warm. It is necessary to reduce the CO2 level to 0.10 percent or lower to avoid these effects. The World Health Organization, European countries, and Japan all have adopted 0.10 percent CO2 as the recommended limit. This requires 15 cfm per person of outdoor air. At this ventilation a minimum amount of tobacco smoke can be tolerated. If we assume that we are going to satisfy only 70 percent of the population who are nonsmokers, and that the smokers (assuming 30 percent of the occupants) are smoking at a rate of 1.7 cigarettes per hour (a minimum amount of smoking), the 15 cfm of outdoor air is required.

Can filters still be used to reduce the amount of ventilation air? The recommended 15 cfm is the amount of ventilation required to dilute contaminants to acceptable levels. Therefore, it is necessary that at least this amount of air be delivered to the conditioned space whenever the building is in use except for times of intermittent or variable occupancy. Properly cleaned air

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may be circulated. But, for other than intermittent or variable occupancy, the portion of outdoor air should not be less than 15 cfm per person.

The proposed revision to Standard 62 specifies rates which vary from a low of 15 cfm per person (for areas such as hotel dormitory sleeping areas, lobbies, and office reception areas) to 60 cfm per person for smoking lounges. A number of applications in the proposed revision of the standard were reduced from 25 cfm per person as specified in the 1981 document to 20 cfm.

ASHRAE Standard 62-1981, although admittedly not comprehensive, remains the most generally recognized standard in the United States for providing ventilation for acceptable indoor air quality. It is, therefore, appropriate to discuss how the standard should be used to achieve its purpose of specifying minimum ventilation rates and indoor air quality that will be acceptable to human occupants, which are intended to avoid adverse health effects. It should be noted that an ASHRAE standard has no mechanism for enforcement. Provisions of the standard must be written into a building code before the standard can be enforced. It represents the collective judgement of people active in the technology being addressed as to what is a realistic and acceptable level of performance.

ASHRAE supports and encourages the use of voluntary consensus standards by the public sector. A major objective of the Society is to establish a formal procedure for obtaining effective participation of public-sector organizations in the identification of the need for specific standards and in the development of those standards. Standard 90, used as a consensus resource document in building codes in all 50 states, is credited with reducing energy consumption in commercial buildings by 25 percent. One of the reasons Standard 90 has had such an impact at the national, state, and local levels is because of the important participation of public sector and private sector in its development. It therefore follows that ventilation standards can be used to ensure acceptable indoor air quality, and a voluntary consensus process can effectively establish ventilation standards.

Another recommendation of ASHRAE's, as stated in its Position Paper on Indoor Air Quality, approved by the Board of Directors on August 1,, 1987, is that the revised Standard 62, when approved, be widely disseminated and referenced by building codes.

Increasing research is another recommendation presented in the position paper, which is guiding ASHRAE's indoor air effort. Of particular importance is research on health effects and control through engineered systems of radon, asbestos fibers, unvented combustion appliances, formaldehyde, tobacco smoke, and volatile organic compounds. Every year, ASHRAE invests more than one million dollars in research. The principles behind conducting the research program are that the results benefit all people, it is not just for the present but for the future, and it is not directly aimed at product development but instead at the discovery of generic scientific and engineering principles. Since 1969, ASHRAE has sponsored 14 research projects specifically on ventilation requirements and indoor air pollutants. The Society has set goals to be achieved within the next couple years which will increase its expenditures in research from 1.25 million to 2 million dollars, and which will triple research expenditures in the areas of occupant health and safety, including indoor air quality.

Findings from one such ASHRAE research project, "Indoor Air Quality Evaluation of Three Office Buildings," were presented at the third annual ASHRAE-sponsored indoor air quality conference, April 11-13, 1988, in Atlanta, Georgia. This was the first documented study of an office complex specifically constructed to minimize indoor air pollution. In the study, this complex was compared with two other similar office complexes that were not specifically designed to reduce pollutant levels. Little documented data on pollutant concentration in offices are available, making the findings of this study extremely important. The ability to field-measure existing levels of

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pollutants and to determine their concentration levels in operating conditions will aid in the assessment of health effects of various indoor pollutants.

An area in which federal government involvement is greatly needed is in research. ASHRAE specifically states in its position paper that support by the federal government for research in all non-proprietary areas of indoor air quality, including health effects, measurement methods, modeling, and control technology, should be substantially and selectively increased. The industry desperately needs research so that building designers, owners, landlords, employers, and tenants alike can know what acceptable indoor air quality is--when and whether you have it and how to correct deficiencies if they occur.

Legislation, which is taking a research oriented thrust, will help provide this data. Specific needs include:

* Exposure and dosage data and basic physiology information to establish target levels for known harmful contaminants.
* Ventilation efficiency...in both dilution effectiveness as well as dynamics of air distribution; system design, such as VAV boxes; and even dynamics of air from diffuser to the occupant in a room. In this regard we must dispel the myth of 5 cfm per person minimum and re-establish 15 cfm as minimum.
* Development of diagnostic and remedial protocols and practices for monitoring, diagnosing, or remedying buildings demonstrating sick building syndrome.
* Studies of occupant populations to establish cost effectiveness values and payback rates on the cost of health related absenteeism and loss of productivity.

The key to solving current and future indoor air quality problems will be research. Each year, the task of maintaining acceptable indoor air quality becomes more difficult as new chemicals are introduced into our indoor environments and as we learn more about the harmful effects of airborne contaminants.

Greater awareness has resulted in attitude changes which will make all our jobs easier:

* No Smoking. The recognition by management that smoking is inherently harmful to the electronics and to human health has resulted in a commitment to manage that exposure to environmental tobacco smoke.
* Focus on Long-Term Costs Not Short-Term Costs. The short-term cost of air scrubbing can range from 3 to 30 dollars per cfm, but the long-term cost is far greater than even replacing the computers, for it means lost production. How does this compare to building owners looking at short-term cost per rentable square footage going into a mechanical room, versus the long-term cost of losing an entire tenant floor or even owning a non-occupable "sick building."
* Maintenance Mentality. A strong commitment to preventative maintenance is mandatory to keep scrubbing units and mechanical systems operating at peak performance.

ASHRAE will continue to provide guidance for design, installation, operation, and maintenance; develop and promulgate standards; and encourage interactions with other groups that have similar objectives. To identify and characterize factors of the environment that are affected by heating, ventilation, air-conditioning, and refrigeration systems, equipment, operation, and maintenance and that have adverse effects on occupant health and comfort is a challenge continuously addressed by ASHRAE.

It is ASHRAE's concern that we maintain good indoor air quality through energy conscious design. But successful energy conservation and good indoor air quality are highly dependent on building performance. Mechanical systems must be properly maintained in order to provide continuing comfort, air quality, and operating economy.

The challenge will continue for building designers, owners, and operators to balance the quality of the indoor environment with low operating costs through energy efficiency.

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ASHRAE will respond to the need for improved air quality with improved, innovative, and cost-effective solutions. But we must present a uniform platform for addressing this "challenge of the decade." We are challenged to ensure that each individual works in an environment with acceptable indoor air quality, and challenged to ensure that our work force operates in safe and healthy surroundings.

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